Preparation of Naval Facilities
Engineering Command (NAVFAC) Guide Specification
NFGS-01810, BUILDING COMMISSIONING

PHASE I:
Review of Building Commissioning

FINAL SUBMITTAL
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I. Executive Summary

Syska & Hennessy (S&H) has been tasked by NAVFAC to develop a report which reviews the current status of building commissioning in the construction industry. Our research indicates that commissioning is on the rise with the main focus being on HVAC and critical systems.

The result of a successful commissioning process is a building which functions as designed, provides a safe, comfortable and reliable working environment and optimizes its resources (i.e., energy, labor, utilities). As building systems grow more complex, the need for commissioning increases. Therefore the level of the commissioning effort must be tailored to fit the needs of the project. This tailoring provides the most benefit for the lowest cost.

S&H recommends that NAVFAC incorporate commissioning into the building delivery process. By establishing three levels of commissioning, NAVFAC will have the flexibility necessary to reap the full benefits of commissioning.

As part of Phase II, S&H recommends the development of a Building Commissioning Guidebook that will show how commissioning can be integrated into the delivery process. Phase II will also include an in-depth review of the NAVFAC building delivery process, to evaluate the best way to incorporate commissioning into the process. A proposed outline of the Guidebook is provided in *Section VII: Next Steps.*

Very often the responsibility for commissioning a facility is not assigned to any one individual or organization, and as a result, buildings do not function in the manner in which they were designed. In addition improper operation of an efficiently designed system leads to subpar performance. In order for a facility to be properly commissioned it is necessary to assign the task of commissioning during the inception of the project. The party responsible for performing the task of commissioning is called the commissioning agent (CA), whether it be an individual or an organization. This assures that a common thread of responsibility is maintained throughout the construction process.

The role of the CA can be performed by a number of people, depending on the complexity and size of the project. Several factors have been identified which lead to the decision of employing the commissioning process and who should be responsible for its implementation.

- Size and complexity of project
- Knowledge and expertise of design consultants
- Knowledge and expertise of owner's operating staff
- Development of team relationships
- Establishing "ownership" in project
- Funding

- Commitment of owner's time and resources.

These factors address issues such as the level of trust between owner and design consultants, complexity of the facility's systems, availability of owner's staff to provide commissioning oversight, among others. Smaller, less complex projects can typically be commissioned by a technically qualified member of the owner's operating staff, who is familiar with both the design and operation of facility systems. As a project grows larger and more complex it requires a broader range of expertise that can not be found within the owner's staff. In these cases the cost of hiring an organization that specializes in building commissioning is offset by the substantial savings that are generated over the life cycle of the building.

Building commissioning makes economic sense, but is it a functional reality that can be implemented universally to Naval facility projects? Another question that is raised is can the building commissioning process be implemented within the framework of NAVFAC operations. The question warrants further consideration and study of the NAVFAC building delivery process to determine the optimal method of implementing the commissioning process within Naval Operations. A general approach to building commissioning, which accounts for the need for different levels of effort is described below.

On simple renovations or low technology structures a systems startup check list with simple performance measures. These types of measures can typically be performed by the owner's project manager. As a job grows more complicated and the interactions between the owner, design team, and construction team becomes more dynamic the commissioning process acts to facilitate communication between the groups and keep the quality of the final product in the forefront of all team members minds. In addition the party responsible for the commissioning process must also maintain the documentation on decisions made throughout the project, and then develop the training program for the building's operation staff. As the complexity of the facility increases this task grows beyond the means of most project managers, and at this point it makes sense to use a neutral third party to facilitate the commissioning process.

II. Definitions of Commissioning

The following published definitions were collected from various sources and illustrate how different view points yield different definitions. The last definition was developed based on input from NAVFAC.

A. Dictionary Definition

Commission: ready for active service.

B. ASHRAE

Commissioning: The process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent. Commissioning begins with planning and includes design, construction, start-up, acceptance and training, and can be applied throughout the life of the building.

C. NEBB

Building system commissioning is an authorization to act in a prescribed manner to ready all building mechanical and electrical systems for active service.

D. SMACNA

Commissioning is defined as the process of advancing systems from a state of static physical completion to a state of full, demonstrated, and documented working order, according to design requirements, during which time the owner's operating staff are instructed in correct systems operation and maintenance.

E. U.S. Army Engineering Support Center, Huntsville

In the Operation and Maintenance Engineering and Enhancement (OMEE) Program, commissioning includes pre-commissioning checks, functional performance tests, and documentation of all activities.

F. University of Washington

The purpose of the commissioning process is to provide the Owner assurance that the systems have been installed in the prescribed manner and will operate within the performance guidelines. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems to beneficial use by the Owner.

G. Composite Definition

Commissioning is a quality enhancement process, that follows the building design and construction process from inception through occupation by the end user and into the early operational life of a facility. The goal of commissioning is to assure that the facility's performance meets the end user's needs and the designer's intent.

III. Benefits of Commissioning

In almost all cases, commissioning will add value to the building delivery process. However, the extent of the commissioning should match the size, type and complexity of a building and its systems. Since it is difficult to quantify the benefits of commissioning (no substantial published data exists yet), this section focuses on the qualitative benefits of commissioning, based on various sources and case studies. Section IV, "Commissioning Economics", presents various methods on how to justify commissioning and tries to put a dollar value to the benefits described in this section.

A. Energy

Building commissioning will result in a decrease in energy costs over the life of the building. The size of the decrease will depend on the size, location and complexity of the building plus the level of the commissioning effort. Energy savings due to commissioning are attributed to: more effective energy management, efficiently operating equipment and the latest performance data needed to buy energy (deregulation). The following chart shows the potential:

Building Type	Savings, $	Savings, kWh/yr
110,000 ft office	$0.11/ft/yr ($12,276/yr)	279,000
22,000 ft office	$0.35/ft/yr ($7,630/yr)	130,800
60,000 ft hi-tech manuf.	$0.20/ft/yr ($12,000/yr)	336,000

Source: Oregon Office of Energy

Effective energy management can be an impossible task if the correct information isn't collected and organized into benchmarks. Proper commissioning will document this at the design phase and carry it through to the turnover of the building to the owner. This allows the facility manager to effectively plan future energy usage.

The issue of energy management is typically only addressed during design, in the case of new buildings, and through retrofit, in the case of existing buildings. The efforts are directed towards the installation of high efficiency equipment, resulting in cost-justified measures that save the facility energy costs. But efficient use of energy is only a portion of effective energy management.

Controlling the form and time of energy utilization are often over looked in the management of a facilities energy usage. The installation of dual fuel equipment, peak shaving technology, and real time metering provide the operators of a facility with the tools and data to make rational energy usage

decisions that provide for the most economical operation of a facility throughout its life cycle.

The following are key issues in the area of commissioning and energy:

- Interruptible Natural Gas Pricing
- Electrical Utility Industry Deregulation
- Emission Controls
- Energy management controls systems (EMCS)

B. Environmental

One of the purposes of a building is to provide a safe and comfortable environment for its occupants, while minimizing the building's impact on the surrounding ecosystem. These goals are achieved through a number of measures ranging from efficient use of resources to quality assurance activities.

The following are key issues in the area of commissioning and the environment:

- Sound (db) criteria
- Reduction of pollution emission
- Reduction of thermal emission

C. Indoor Air Quality

The issue of indoor air quality (IAQ) has been in the forefront of national attention as news stories convey information of outbreaks of "sick building syndrome". The drive to improve facility performance with tighter construction has lead to problems caused by chemical contaminates being trapped within the structure and causing the occupants to develop health problems. The reaction to this development was a new focus on the flow of air into and out of a building and what that air contains. These measures are collectively known as IAQ.

Commissioning helps bring the design intent and proper operating and maintenance (O&M) procedures from the design phase through into the building operations phase. Since most IAQ problems are caused by improper (or non-existent) HVAC maintenance, commissioning can optimize IAQ and increase the productivity of a building.

- Most facility executives believe a high quality work environment can boost productivity by 10 percent or more. *(Source: National Summit on Building Performance)*

- A Cornell University survey of 4,500 workers in 27 buildings, showed that 50% found climate conditions to be a problem: 51% found areas too warm, 44% found areas too cold, 38% had too little air, 33% considered the air too dry and 31% complained of stale air. In general, the study concluded that "the more sick building syndrome symptoms found in a building, the lower workers rated their productivity at work. *(Source: "Predicting Sick Building Syndrome at Individual and Aggregate Levels", Alan Hedge, William A. Erickson, Gail Rubin)*

- Studies by the International Facility Managers Association (IFMA) and the Building Owners Management Association (BOMA) show that IAQ and thermal comfort are the number one reasons tenants break leases. *(Source: Building Operating Management, May 1997)*

The following are key issues in the area of commissioning and IAQ:

- Worker productivity

- Establish on-going measurement of critical IAQ indicators

- Increased awareness of IAQ issues during all phases of project

- Increased awareness of the IAQ impact caused by the methods and materials used in construction

- Awareness of Volatile Organic Compounds (VOC) and their impact.

D. Staffing and Training

The transition from acceptance of construction to the operation of a facility is often poorly executed due to the loss of construction documentation and poor planning of an O&M program. The development of a comprehensive training program early in the project that is modified and updated as the project evolves can make the transition of the facility operation to the normal staff more beneficial to the owner by informing the staff of all of the facility's features and proper equipment operation.

In addition to the formal equipment training provided by the manufacturers and vendors, the commissioning agent can provide overall system training, focusing on the interaction between equipment and systems. Developing the commissioning plan becomes a team effort between the commissioning

agent and the prospective O&M staff.

The following are key issues in the area of commissioning and training:

- Cost effective development of staff training through presence of single organization from the program stage though operational testing & start-up.
- Training effort of vendors is coordinated by commissioning agent
- Hiring and qualifying O&M staff
- Overall system-based training in addition to equipment-based training.

E. Power Quality and Reliability

As buildings become more and more dependent on computers and technology, electrical power quality and reliability become more and more critical. Commissioning verifies that the electrical system (including the emergency power system) is operating as designed and the maintenance procedures recommended by the manufacturer are delivered in a usable format to the O&M staff.

The following are key issues in the area of commissioning and power quality:

- Establishment of power quality measurement and monitoring
- Deregulation's effect on power quality
- Training of staff in power quality issues and troubleshooting
- Introduction of power quality issues during program and design.

F. Operating & Maintenance (O&M) Documentation

A building delivered with accurate, centralized O&M documentation is worth more to the owner than a building delivered with boxes of scattered manufacturer's literature and a pile of drawings. The commissioning plan provides the framework for the O&M manuals, and should be an integral part of the final O&M manuals. Commissioning also provides a means to validate the procedures identified in the O&M manuals.

The following are key issues in the area of commissioning and O&M documentation:

- NAVFAC's OMSI program provides a perfect environment to develop a commissioning plan and to perform commissioning.

- Effective O&M program development is often hampered by incomplete O&M submittals collected during construction.

- As part of the commissioning process the commissioning agent compiles all the required documentation and develops the O&M program and training parallel to the construction allowing for a quicker transition to operation by normal staff.

G. Life Safety Systems

The current method for installing and testing life safety equipment is to treat each device as a stand alone system with little effort put forth to test the life safety system as a whole. This may lead to gaps in coverage or problems in the interaction between alarm and extinguishing systems.

The fire alarm system is one of the basic building blocks of the building life safety system. Due to NFPA requirements most vendors commission the individual devices on the fire alarm system. Vendors frequently do not test and verify the interfaces between the fire alarm system and other systems such as HVAC, security, and elevator systems. Proper fire alarm system commissioning will also verify system response from multiple alarms and degraded mode operation. This will give the building owner documented confirmation that the system is complete and operational.

The following are key issues in the area of commissioning and life safety systems:

- Single-vendor control systems (e.g., the fire alarm system) very often are changed by the vendor during construction based on new technology, scheduling, etc. The original design issues may get lost. The commissioning agent will provide an independent third-party view from the standpoint of operating and maintaining the system for the next 50 years.

H. Quality Assurance/Quality Control

"Getting what you pay for" is an important by-product of commissioning. Although the responsibility of the design is still the engineers's, and the responsibility of the construction still belongs to the builder, the commissioning agent provides an independent third-party view from the

standpoint of ongoing operations and maintenance. Very often the design engineers do not have the practical hands-on experience to design and witness the system and equipment testing process. Non-working or incomplete systems can get passed onto the owner as the construction team starts to leave the job site.

The following are key issues in the area of commissioning and quality assurance:

- Maintain design intent through project
- Special issues concerning design/build projects
- Independent third-party viewpoint
- Focus on project close-out
- Define "complete" and "substantially complete"
- Help owner to approve and validate construction invoices.

I. Operating & Maintenance (O&M) Awareness

The use of commissioning can provide a common thread through each phase of the project. This common thread keeps the long range economies of O&M in the forefront. Due to the specialization of the various groups involved in facilities projects, some decisions can be sub-optimized. For example the architect in accordance with one of his objectives to maximize available floor space, will instruct the mechanical engineer to utilize AHUs which are placed above the suspended ceiling. This practice helps the architect achieve the objective of low construction cost per square foot, but may increase operating costs per square foot over the forty to fifty year life of the building.

The following are key issues in the area of commissioning and O&M awareness:

- An O&M representative attends the project meetings
- Common thread (ideally, the commissioning agent stays on board from programming through the first year of O&M).

J. Value Engineering

The practice of value engineering focuses on the functions performed by the facility and its equipment. It separates essential and non-essential functions

and eliminates the functions that represent unnecessary expenditures (initial costs) that yield little additional functionality. The typical goal of value engineering is the reduction of construction costs without impacting facility functionality. When combined with the experience of a commissioning agent, the tool of value engineering takes a life cycle view and equipment selection review and functionality analysis keep the operation of the facility over the course of years in mind.

K. System v. Equipment Focus

Typically when a facility construction project is nearing completion vendors are required to perform functional tests and training on their equipment. This leads to an equipment based focus by the staff, who are never actively trained in the SYSTEM operation and interaction of the equipment in its role within the building system. The building commissioning process provides performance tests and operation training for the facility as a whole and incorporates the interaction between systems.

The following are key issues in the area of commissioning and system v. equipment focus:

- Single-vendor systems.
- Multi-vendor systems.

L. Performance Standards and Regulatory Compliance

On a large, complex building the design-bid-build process can take many years. During this period, standards or codes can change in terms of operations and maintenance. The following are some examples.

- Energy Act of 1992
- ISO9000
- JCAHO
- OSHA
- ASHRAE.

M. Control Systems

Since building control systems are traditionally the last systems to be completed, and are frequently not completed until after building occupancy, proper commissioning is required for a true evaluation of system scope and

functionality. Building control systems are typically microprocessor-based, software-driven systems that are implemented by local vendors. Stock software is modified by the local vendor, who also engineers interfaces to other systems, to comply with requirements that are site specific. The modified software and hardware is frequently not tested until it is operational at the job site. Full testing and commissioning is commonly not done by the contractor as it is too long and complicated a process. Owners must rely on an outside party to enforce and oversee the testing by the controls contractor to ensure that all devices, software, and interfaces to other systems are tested in all modes and conditions. This will give the owner a baseline condition of the system where everything is operational.

IV. Commissioning Economics

Building life cycle cost is the funding required to design, build and operate a facility from inception through demolition. The process of analyzing the life cycle cost takes into account the time value of money.

The costs associated with the design, construction and operation of a facility are estimated from past projects of a similar nature. These costs are then allocated across the life span of the facility, using a cash flow diagram. The various cash flows are then discounted to account for the effect of time on the value of money. The various discounted cash flows are then totaled to yield the net present cost of the project. The net present cost is used to compare projects that have different life spans and distribution of cash flows.

The economics of commissioning spans the life of a facility, and the greatest benefits of commissioning are usually realized in reduced operating costs **each** year. For example, in one scenario, the commissioning process increases the cost of design and construction by one percent (1%), but reduces the annual operating cost by five percent (5%). Using the construction cost (X) as a basis, the standard design fee of ten percent (10%) of construction cost for design costs, and an assumption that the annual cost to operate the facility is five percent (5%) of construction cost. Perform a simple economic analysis.

Assumptions:

- Cost to Construct Facility = X
- Building Life is 50 years
- Cost of Capital (interest rate) is 10 percent
- Design & Construction occurs prior to occupation year zero
- Present Worth Factor of Design Fee = 1.21
- Present Worth Factor for Construction Cost = 1.1
- Present Worth Factor of Annual Costs for Fifty Years = 9.914

Building Phases	**Non-Commissioned Building**	**Commissioned Building**
Design	$0.1X$	$0.101X$
Construction	X	$1.01X$
Annual Operation	$0.05X$	$0.045X$
Life Cycle Cost (net present cost)	$1.717X$	$1.704X$

Given these assumptions for every million dollars of construction cost the commissioning process would have saved $13,000 over the life of the facility. Now this is a scenario with a significant amount of negative assumptions. The commissioning process very often reduces the cost of construction, and if the assumption was made that the design and construction costs remained constant

between the two situations then the savings generated by commissioning over the life of the building would be approximately $50,000 per million spent in construction.

This simple analysis does not address other benefits of commissioning, such as IAQ litigation avoidance, and improper system installation remediation, which are difficult to assign a dollar value to.

In order to further demonstrate the economics of commissioning, a comparison is made of the costs associated with facility construction and operation between facility types, on a cost per square foot basis. We have used cost data from various sources to establish a baseline life cycle cost for a facility without the use of the commissioning process. Adjustments were made to the cash flows to reflect expected benefits of commissioning. The detailed results of this analysis are presented in Appendix B. A summary of the findings is provided below.

Financial Impact of Building Commissioning (per square foot)

Building Type	Life Cycle Cost per Square Foot (Net Present Cost @ 10%)		Cost Savings	Cost to Commission	Design Fee	Internal Rate of Return
	Non-Commissioned Building	Commissioned Building				
Corporate Office	$1,548.24	$1,275.65	$272.59	$2.83	$7.80	115.34%
Financial	$1,590.31	$1,324.73	$265.58	$3.16	$8.70	100.75%
Medical	$2,617.11	$1,948.30	$668.81	$7.62	$21.00	105.11%
University	$828.13	$729.12	$99.01	$3.54	$7.90	33.52%
Research	$3,009.70	$1,954.01	$1,055.69	$8.17	$22.50	154.85%
Industrial	$1,417.54	$740.58	$676.96	$1.82	$5.00	446.84%

V. Commissioning Approach

Current trends in commissioning suggest it is most cost effective to begin the commissioning process during the owner's program development, and carried on through the entire project. However to be cost effective, the level of commissioning should match the size and complexity of the building. The following shows three levels of commissioning.

Level 1: Basic Commissioning

Commissioning procedures are spelled out in construction documents which are to be performed by the constructor. The owner's project manager will witness the commissioning process and provide quality control throughout all procedures.

Level 2: Comprehensive Commissioning

A third party, independent from the designer and constructor, is tasked with the responsibility for the commissioning process. The commissioning agent will have a level of responsibility and authority over the activities of other project team members. This is spelled out in the various contract documents. The commissioning process at this level may use statistical quality sampling methods to improve the cost effectiveness of the process for the systems being commissioned.

Level 3: Critical Systems or Systems Integration Commissioning

As in Level 2 commissioning, the responsibility of commissioning is assigned to an independent third party, but the depth and scope of the process is magnified to address the special needs of the critical systems involved. The cost of the additional effort is offset by the high cost of a system failure in the future.

A. Commissioning Services in New Facilities (Levels 2 & 3)

1. Programming Phase

   The Commissioning agent works with the owner to develop a formal program document. This document spells out the requirements of the new facility and should include but not be limited to:

   - size (square footage, footprint, # of floors)
   - staffing levels
   - process functions
   - operating and maintenance requirements

- budgetary system operating costs

The more information the owner can contribute in the program stage the more completely the facility will meet the needs of the owner's organization upon completion. The Commissioning agent acts as a consultant in pointing out critical decisions that impact the future design and construction of the proposed facility.

2. RFP for A/E Services

The next step in the process is to develop a specification for the procurement of Architect/Engineer (A/E) services. The specification incorporates the owner's program information into a format that explains out the responsibility of the owner, commissioning agent, and A/E in the development of the facility design documents.

The completed RFP is sent to qualified firms in accordance with the owner's standard practice. The commissioning agent can provide guidance in generating a list of suitable vendors for the project and should be present at any pre bid meetings that may be held.

Upon receipt of the bids the evaluation of the proposals should be conducted jointly by the owner's project manager and the commissioning agent. Any inconsistencies between proposals should be identified and their potential impact calculated and clarified so that a sound judgement can be made by the owner in award of the contract for design services.

C. Facility Design Development

The development of the final design documents is the joint responsibility of the A/E firm, the owner and the commissioning agent. The design intent further refines the owner's program and applies the various codes and engineering standards producing the design guidelines.

It is at this stage that the commissioning agent documents the design intent and program requirements. The commissioning agent's responsibility is to ensure the program elements are being met in the design documents. Perhaps the most important functions at this stage are:

- Ensuring the facility is designed for effective O&M (eliminate O&M road blocks)

- Designed for ease of monitoring and testing/validating the various systems

- Value engineering energy savings

Other responsibilities include documenting the design parameters which should include the following:

- Environmental and air quality requirements

- Basis of design and design parameters

- Levels of illumination

- Power distribution capacity and diversity

- Energy performance criteria for BMS/EMS systems

- Description of all operating systems

- System operations under the following conditions:
  - Normal occupancy
  - Partial occupancy
  - Emergency situations.

D. Construction Specification

The construction specifications are developed by the A/E with input from the CA to clarify interactions between the CA and the construction contractors during the construction and acceptance stage. In addition the CA shall provide support documents for the specification that links the commissioning plan to the appropriate sections of the construction specification.

E. Commissioning Specification/Plan

The commissioning plan is developed by the CA and it is a written description of the commissioning process for the facility to meet the needs of the owner as spelled out in the Owner's Program. It should contain the following information:

- The initial design intent

- Staffing, skills and man-hours required for the process

- Listing of observations and inspections to be made during construction
- Listing of equipment and systems that will be functional tested
- Schedule and sequence to provide O&M/testing documentation
- Acceptance procedures
- Training requirements
- Requirements for timely delivery of submittals, operations manual and maintenance manual materials, and other documents.
- Identification of equipment and systems to be commissioned
- Detailed description of commissioning schedule
- Detailed identification of what must be completed before next operation may proceed (checklists)
- Detailed description of the responsibilities of each party
- Detailed description of the methods to be used by each party
- Detailed description of the observations to be made
- Detailed description of the submittals that are required to support the commissioning process
- Detailed description of the documents to be provided along with the identification of the responsible party
- Detailed description of the verification procedures along with the identification of the parties involved and the responsible party
- Detailed description of the functional performance test procedures along with the identification of the parties involved and the responsible party
- Specification of acceptable performance for all equipment, controls, and systems

- Sample report formats
- TAB requirements

The completed commissioning plan should be reviewed by the owner, CA, and A/E to assure compliance with the owner's needs.

F. Construction Phase

During the construction phase the CA has a number of responsibilities that provide the activities necessary to assure that the facility meets the requirements of the owner when complete and provide for a smooth transition from start up to normal daily operations.

One of the CA's key roles is the enforcement and monitoring of the commissioning plan. The CA provides site inspections and witnesses test procedures to assure compliance with the specification and commissioning plan. It should be noted that it is not the function of the CA to direct the activities of the construction contractor or associated subcontractors, merely to enforce compliance to the specification in regards to facility performance. The specification and commissioning plan spell out the requirements imposed on the constructor and the CA makes sure that the constructor fulfills this obligation. This will include:

- Commissioning meetings
- Monitor pre-start checks
- Equipment and systems start-up.

Additionally the CA must update the commissioning plan to reflect approved changes to the scope of the project. If additional equipment needs to be incorporated into the design to address a change in the owners requirement, then the CA must address this addition in the commissioning plan to allow for testing and start up of this additional equipment.

The development of the facility O&M manual and training program also begins during the construction phase of the facility. In order for a complete O&M manual to be created, it is necessary for the CA to monitor and maintain records on the timely and complete submittal of equipment documentation and manuals. This information is vital in the proper development of an O&M manual. A natural outgrowth

of the development of the O&M manual is a program for training the building's staff in its operation. This training program should be developed in such a way as to allow the training of new employees in the future.

G. Acceptance Phase

During this phase the CA will work with the various contractors to perform operational and functional performance or commissioning checkouts as outlined in the commissioning specifications. This phase is usually done in the last phases of construction. Operation and maintenance training can begin at this point. The CA will verify the following:

- Verification of systems integration or operation
- Functional performance testing
- O&M manual review
- O&M training.

H. Post Acceptance Phase

At this stage construction has been completed and most of the commissioning process is complete. All equipment that did not pass the acceptance phase at this time would be modified and retested.

A formal or pre-final commissioning report would be turned over to the owner during this phase, with the final to be delivered at the conclusion of the post acceptance commissioning activities.

On going commissioning activities would be as follows:

- Develop as-built documentation
- Performance audits
- O&M audits
- Verify and document minor system modifications
- Verify and document major system modification

B. Commissioning Services in Existing Facilities

1. Facility Audit and Assessment

The first step in commissioning an existing facility is to evaluate the physical and operational condition of the structure and its support systems. The audit process is used to account for each piece of equipment and its condition. This allows for the prioritization of system improvements and commissioning efforts.

Facility Audit activities typically include the following:

- Review of the original construction documents
- Verification of as built documentation
- Review of previous TAB reports
- Review of previous energy surveys
- Performance of TAB and energy survey to obtain current information
- Review of maintenance records and history
- Review of facility improvement project records

2. Master Facility Plan

A Facility Master Plan is a document which results from the Facility Audit and Assessment. It is created to communicate the long term plans and goals for the future capital and operational improvements of a facility. A portion of the Master Facility Plan will identify the act of commissioning as an integral part of an organization's efforts to reach its facilities related goals.

At this point a commissioning agent is brought on board to develop a formal commissioning plan. The commissioning plan should be similar to the document described in Section V Part A: "Commissioning Services in New Facilities".

3. Implementation

After selection of a Commissioning Agent the commissioning plan is fully developed and implemented. The appropriate tradesmen are hired to facilitate the performance of the required tests and balancing. Once systems are in compliance with requirements the

process moves on to acceptance.

One of the CA's key roles is the enforcement and monitoring of the commissioning plan. The CA witnesses test procedures to assure compliance with the commissioning plan. The plan explains the requirements imposed on the contractors and the CA makes sure that the contractors fulfill these obligation.

The development of the facility O&M manual and training program also begins during the implementation phase of the process. A natural outgrowth of the development of the O&M manual is a program for training the building's staff in its operation. This training program should be developed in such a way as to allow the training of new employees in the future.

4. Acceptance

During the acceptance phase the Commissioning Agent finalizes the Operation and Maintenance Manuals and tests the procedures detailed within the document. Systems are tested as a whole and performance data is accumulated to assure compliance with requirements and for future building operation monitoring. The facility management staff is trained in the proper O&M of the facility and in the proper use of the information generated by the commissioning effort.

During this phase the CA will work with the various contractors and owner's staff to perform operational and functional performance or commissioning checkouts as outlined in the commissioning plan. This phase is usually done as the last phase of commissioning. Operation and maintenance training can begin at this point. The CA will verify the following:

- Verification of systems integration or operation
- Functional performance testing
- O&M manual review
- O&M training.

5. Post Acceptance

At this stage commissioning has been completed. All equipment that did not pass the acceptance phase at this time would be modified and retested.

A formal or pre-final commissioning report would be turned over to the owner during this phase, with the final to be delivered at the end of the post acceptance commissioning activities.

On going commissioning activities would be as follows:

- Develop as-built documentation
- Performance audits
- O&M audits
- Verify and document minor system modifications
- Verify and document major system modification

VI. Commissioning Value Matrix

The variations in project size, complexity, critical or highly specialized systems, and owner requirements necessitate describing the commissioning process in terms of different levels of commissioning (refer to previous section).

The next two pages show a sample matrix which identifies some common facility types and building systems. In the field of the matrix at the intersection of a particular facility type and a building system component, the appropriate level of commissioning is identified by the number corresponding to the level of commissioning.

Commissioning Value Matrix

SYSTEMS	FACILITY TYPES	Data Center			Medical			Research				Office		Housing								
		Small	Medium	Large	Clinic	Super Clinic	Hospital	Bio-Medical	Chemical	Weapons	Scientific	Low Rise	High Rise	Low Rise	Hgh Rise	Maritime	Recreational	Public Assembly	Hanger	Power Plant	
Architectural	**Roofing**																				
	Vertical Transport																				
	Special Systems																				
	Exterior Closures																				
HVAC	**AHU's**																				
	Chiller																				
	Boiler																				
	Pumps																				
	Humidification																				
	Testing, Adjustment, Balancing (TAB)																				

Commissioning Value Matrix

SYSTEMS	FACILITY TYPES	Data Center			Medical			Research				Office		Housing								
		Small	Medium	Large	Clinic	Super Clinic	Hospital	Bio-Medical	Chemical	Weapons	Scientific	Low Rise	High Rise	Low Rise	Hgh Rise	Maritime	Recreational	Public Assembly	Hanger	Power Plant	
ELEC	**ATS**																				
	Emer. Generator																				
	Switchgear																				
	MTS																				
ELEC	**UPS**																				
	Emer. Lighting																				
Fire Protection	**Sprinkler**																				
	Smoke Management																				
	Fire Detection																				
	Smothering Agents																				

Commissioning Value Matrix

SYSTEMS	FACILITY TYPES	Data Center			Medical			Research				Office		Housing								
		Small	Medium	Large	Clinic	Super Clinic	Hospital	Bio-Medical	Chemical	Weapons	Scientific	Low Rise	High Rise	Low Rise	Hgh Rise	Maritime	Recreational	Public Assembly	Hanger	Power Plant	
Bldg Management	**Inputs**																				
	Outputs																				
	Database																				
	Programing																				
	Interlocks																				
Misc.	**Medical Gas**																				
	Material Handling																				
	Fuel Systems																				
	Water Purification																				
	Waste Treatment																				

VII. Next Steps

The question that remains is how to incorporate Commissioning into the NAVFAC building delivery process. Our goal for Phase II is to develop a Commissioning Guidebook which documents the decision making process for determining the level of commissioning, and then spells out step-by-step how NAVFAC obtains, funds and monitors commissioning services.

The following a sample outline for a Commissioning Guidebook:

A. Introduction
B. Project Commissioning Economic Analysis
C. Commissioning Value Matrix
D. Level One: Basic Commissioning
    1. Contractor responsibilities
    2. NAVFAC responsibilities
E. Level Two: Comprehensive Commissioning
    1. Commissioning Agent responsibilities
    2. Contractor responsibilities
    3. NAVFAC responsibilities
F. Level Three: Critical Commissioning
    1. Commissioning Agent responsibilities
    2. Contractor responsibilities
    3. NAVFAC responsibilities
G. Commissioning Documents
    1. Commissioning Plan
    2. System Checklists
    3. Performance Reports
    4. Inspection/Verification Reports
    5. Commissioning Guide Specification, NFGS 01XXX
H. Commissioning Contract Approaches
I. Commissioning Training
J. Commissioning Process Chart
K. Recommissioning
L. Sample Commissioning Schedules